Association for Information Systems
AIS Electronic Library (AISeL)

ICIS 2010 Proceedings

International Conference on Information Systems (ICIS)

2010

Want Pudding? An Analytic Model of the Benefits and Constraints of Process Standardization in Services

Matt Wimble
MMichigan State Universityichigan State University College of Law, wimble@bus.msu.edu

Brian Pentland
Michigan State University, pentland@bus.msu.edu

Derek Hillison
Florida State University, dhillison@gmail.com

John Tripp
Michigan State University, john_tripp@baylor.edu

Want Pudding? An Analytic Model of the Benefits and Constraints of Process Standardization in Services

Research-in-Progress

Matt Wimble
Michigan State University
wimble@bus.msu.edu

Brian Pentland
Michigan State University
pentland@bus.msu.edu

Derek Hillison
Florida State University
dhillison@gmail.com

John Tripp
Michigan State University
tripp@bus.msu.edu

Abstract

We develop a model to analyze the benefits and constraints of process standardization under environmental conditions which demand a high degree of sequential variety. The model shows that the enabling value derived from standardization is an exponential function of the number of services offered and the number of service providers. The model also shows that conventional process definitions impose constraints that can result in a loss of flexibility. In a service context, loss of flexibility implies a loss of value. This loss of value is a combinatoric function which is likely to outweigh the exponential gains from standardization. We argue that designers and managers are likely to drastically underestimate the magnitude of this loss of flexibility precisely because it is combinatoric. We show that a constraint-based approach to process definition is superior to an enumeration-based approach when the environment demands high sequential variety, which is often the case in service environments.

Keywords: Business process modeling, Analytical modeling, Service process, Standardization

Introduction

> "If you don't eat your meat, you can't have any pudding! How can you have any pudding if you don't eat your meat?!"-*Pink Floyd, Another Brick in the Wall*

While specifying the sequence of food consumption might represent good dietary guidelines for children, such strong sequential rigidity would be seen as intolerably bad service at a restaurant. Some customers want their pudding first; some may *only* want pudding. In the world of information systems, a similar class of problems arises whenever we attempt to create standards that specify what actions or services are available and the sequence in which they can occur.[1]

Conventional ideas about process standardization are derived from the classic manufacturing context, so they focus on the avoidance of and control of exceptions to improve quality (Oakland, 1996). As these concepts are applied to the delivery of services, key differences from traditional processes must be taken into account. Service quality is often defined by the ability to accommodate, rather than avoid exceptions, thus a new approach to process standardization is needed. In a conventional manufacturing context "one best way" is the starting point for defining a process. In modern services, the production sequence needs a high degree of flexibility because output is difficult to measure and the consumer provides inputs to the process (Argote, 1982). As a result, the "best way" in services is often to accommodate many ways. Services have even been defined by Pine and Gilmore (1999) in terms of flexibility: "Services are intangible activities customized to the individual request of known clients."

In this research-in-progress paper, we develop an analytic model that allows us to compute the relative benefits and losses associated with process standards as a function of the size of the service lexicon, the number of service providers, and the number of services actually selected (which may be a subset of the full menu). The research question is: how do these factors affect the relative value of a process standard? Further, we explore the possibility that different kinds of process standards may have different effects. In particular, Kumar and Zhao (1999) proposed a different method for defining processes, which starts from an open set and refines it by saying what is *not* allowed, but this approach is not generally used in practice. Our model suggests that the potential benefits of defining a process standard in this way may be substantial in an environment with high sequential variety, such as a service context.

We submit as a research-in-progress because the analytic model predicts that the loss of flexibility can outweigh benefits largely due to the sequential nature of processes. Next steps include: (1) further refinements to the model, such as including handoff or transaction costs and including differential efficiency between service providers; and (2) case studies of selected industries to see if the predicted phenomenon occurs in the field. Because of its simplicity and general mathematical form, the model is applicable to a wide range of IT contexts, ranging from service-oriented architecture (SOA) to inter-organizational systems (IOS).

Theoretical Background

A standard, or a "technical specification adhered to by a producer" (David and Greenstein, 1990) can specify what and how business processes are executed in transactions between partners (Bala and Venkatesh, 2003). These standards have value because they facilitate collective action, but they do this by constraining the set of possible actions and sequences of actions that are allowed (Markus, et. al., 2006). This tension between constraint and enablement can be seen through the influence of Taylor (1911) and standards setting organizations such as ISO, and the recognition of desirable flexibility in current supply chain systems (Gosain, et al.,. 2004-05)

To the degree process standardization has focused upon the identification, control, and enforcement of the appropriate sequence of actions, it enforces the "one best way" to accomplish a goal. Quality in this context is defined by lack of variation and the minimization or elimination of exceptions (Oakland, 1999). While this approach

---

[1] In this paper, we use the terms like *action*, *activity*, *task*, and *service* to denote parts of a process. This is because the findings of our mathematical model apply across settings where different vocabulary is conventionally used.

makes sense in a classic manufacturing context, the nature of production in a service context is inherently and dramatically different.

Services exhibit the characteristics of inseparability, intangibility, and heterogeneity (Shostack, 1977). Inseparability refers to the idea that the consumer, often acting as a producer, provides inputs to the production process and that consumption and production often occur simultaneously (Shostack, 1977). Intangibility refers to the idea that output of a service is often not inventoried, often does not consume physical space, and is not easily measured (Carmen and Langeard, 1980). Inseparability and intangibility lead to heterogeneity in production sequence because services vary day-to-day and customer-to-customer (Parasuraman, et. al., 1985).

It is important to note that in traditional processes, such as classic manufacturing, many production sequences are infeasible due to simple physical constraints, and this is true in some service contexts as well. Even in modern build-to-order manufacturing, variability is often in the production inputs, not the production sequence due to physical constraints. For example, a modern manufacturer may provide many different paint choices for a product, but the painting task generally occurs at the same point in the production sequence regardless of choice of paint. Dependence upon past procedures and ways of doing things is problematic in services, since service providers constantly face with new situations that require novel solutions (Bowen and Ford, 2002). In the parlance of traditional process definition, service processes involve lots of exceptions in sequence. Some customers want their pudding first.

Service processes involve "exceptions" to such a degree that the goal in services is not to codify "one best way", but rather to accommodate as many ways as possible. In services, flexibility is the goal. The heterogeneity inherent in service processes manifests as variety that can be seen as a sign of the flexibility that is necessary for high service quality (Feldman, 2000). The ability of a service provider to deal with a wide variety of situations is a mark of high customer service (Zeithaml, et. al., 1990; Cronin and Taylor, 1994) and a key factor in retaining customers in service environments (Keaveney, 1995).

In the subsequent sections, we develop an analytic model that captures the essence of this phenomenon. The model shows that the benefits of process standards grow exponentially as the number of steps and the number of providers grows. But the loss of flexibility grows even faster, because it is a combinatoric function. Because the number of combinations is so large, system designers and managers are likely to radically underestimate its magnitude due to decision making biases associated with combinatoric functions (Tversky and Kahneman, 1974).

Analytic Model

Like any analytic model, we depend on simplifying assumptions to develop our analysis. First, while many process modeling approaches allow for parallel processing, this model assumes that process steps occur sequentially. Given the combinatoric nature of sequencing, the relative magnitude of the functions derived will still apply at scale. In other words, even if some process steps occur parallel, it does not invalidate the findings. Second, we assume that all sequences are equally valuable. Given the uncertainty inherent in service provision environment, it may be difficult to say a priori which sequences may be more valuable or occur more often than others, and their relative value may change unpredictably over time. In qualitative terms, the model depends on the assumption that having more choices is better than having fewer choices. Secondly, while the model explicitly ignores several factors which also impact process standardization. This simplification is done to provide a clear illustration of the concepts presented, not to diminish the potential impact of factors left out of the model. This is analogous to the "in a vacuum" assumption when modeling physical systems. By ignoring well-known factors, such as friction and wind resistance, theorists are able to provide clear models of underlying phenomena. An example of this which relates to information systems is Metcalfe's Law for telecommunication systems, whereby the value of the network is an exponential function, n(n-1), of the number of network users.

Enabling Flexibility

First, we will model what happens when all available services are used as part of the process. After that, we will address what happens when a subset of these actions are selected. Our model defines system flexibility as the number of possible ways that a particular sequence of S services provided can be completed by P service providers (e.g. Bob can serve the customer pudding, rather than Ann). We start with the simplest expression of this, and then discuss the impact of changes in the number of providers or services. The number of ways to assign S services provided between P service providers is

1) $$P^s$$

To illustrate this concept consider an example process with 4 services provided, A through D, and three service providers (1, 2, 3). In this case there would 3^4 (or 81) ways in which one could assign the 4 services provided to the 3 service providers. Table 1 illustrates this principle, by showing some of the possibilities.

Table 1. Service assignment of a 4-service & 3-provider process

	Service A	**Service B**	**Service C**	**Service D**
Option 1	1	1	1	1
Option 2	1	1	1	2
Option 3	1	1	1	3
…	…	…	…	…
Option 80 (P^s-1)	3	3	3	2
Option 81 (P^s)	3	3	3	3

If services provided are always sequenced A-B-C-D (i.e. one prescribed sequence), how many more scheduling options are available to a firm that uses a sequentially unconstrained system? Since the service provider could have performed all the services provided in the process, the service provider would have had one way to assign the services provided in this process. Following that logic the number of additional paths of execution V available to management with P service providers and S services provided is

2) $$V = P^s - 1$$

Note in equation 2, the value of a process standard increases to a given firm as the number of services provided, S, increases and the number of providers, P, increases. This leads to two propositions:

Proposition 1: The enabling benefits, in terms of assignment flexibility, of adopting service process standards increase as a polynomial function of the number of service providers adopting the standard

Proposition 2: The enabling benefits, in terms of assignment flexibility, of adopting service process standards increase as an exponential function of the number of services provided.

Constraints on Flexibility

After considering how services provided in a sequence can be assigned to various service providers in the process, it is necessary to consider how the services provided can be sequenced. Some customers want their pudding first. The amount of permutations, the possible combinations of service sequences, from a service lexicon of size *S* is

3) $$S!$$

Now consider that we implement the service sequence standard using a system which constrains the process to "one best" service sequence. In this case by constraining the process to one sequence, where the loss of sequences is

4) $$S!-1$$

service sequences available to management. The important point here is that the loss of flexibility is a combinatorial function of the number of services provided which can be performed in any order. The nature of the constraint on flexibility leads to the following proposition:

Proposition 3: The constraining costs to a system, in terms of reduced flexibility in service sequence, from establishing a sequence-standard increase as a combinatorial function of the number of services provided.

The Tradeoff between Enabling and Constraining Flexibility

In terms of system flexibility, there is an advantage to letting different providers serve the pudding. We have also seen that some customers want their pudding first and how defining a provision sequence a priori is likely to deny them their pudding. To explore the interaction between service assignment and service sequencing effects work it is useful to consider an example with a relatively small number of services provided and service providers. Consider a 7 service work process with 4 service providers. This leads to 7! or 5,040 service sequences and 4^7-1 (16,363) possible service assignments. This yields a total number of possibilities of 82,570,320. So the total number of possibilities V with S services provided and P service providers is

5) $$V = S!P^s$$

Once it becomes apparent that large losses in flexibility result of constraining the service sequence to one sequence, the question becomes how much gain from assignment flexibility necessary to justify the loss from constraining service sequencing? How many service providers must be added in order to justify losing flexibility in sequencing? At this point we have a cost of S!-1 where S is the number of services provided and a benefit of $P^S - 1$ where P is the number of service providers. Solving $S! - 1 = P^S - 1$ for P reduces to

6) $$P = \sqrt[s]{S!}$$

This is the number of service providers necessary to justify the constraint on flexibility imposed by process standards. Because factorial functions often result in solutions that explode in size it would be informative to graph this function to show how this relationship behaves as service size increases. Surprisingly, this relationship is nearly linear as shown over a large number of services in figure 1 and a small number in figure 2.

Figure 1. Tradeoff between enabling and constraining flexibility

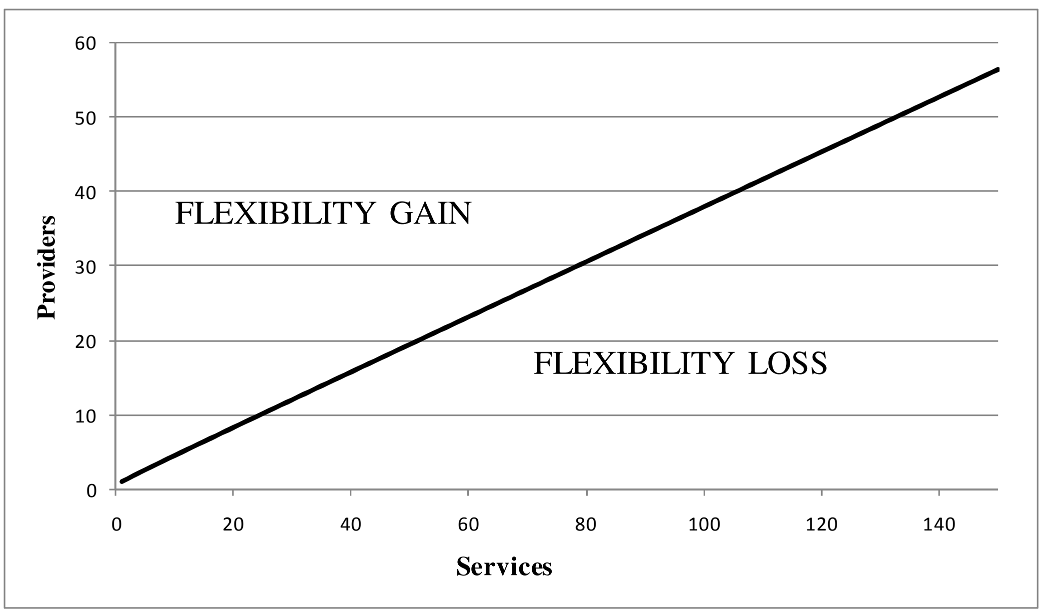
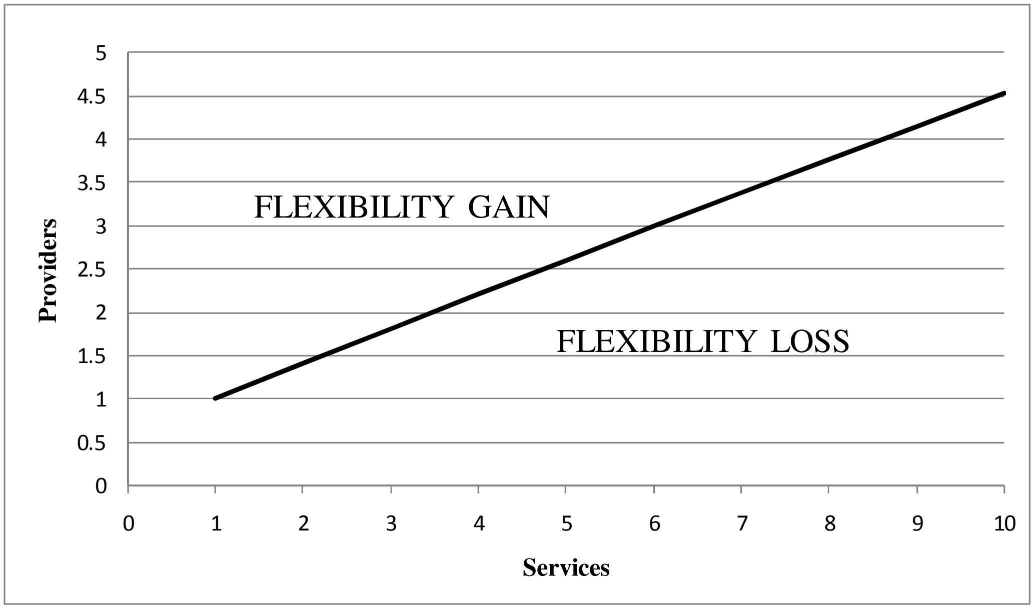


Figure 2. Tradeoff between enabling and constraining flexibility-10 Services



Selection of a subset

Given our base model, equation 6, outlined above we now consider what happens when a subset C if selected from a service lexicon S. The number of ways to select C groups of services from S possible services is

$$\text{7)} \qquad \frac{S!}{(S-C)!}$$

So, we now substitute equation 7 for S into equation 6 yielding

$$\text{8)} \qquad P = \sqrt[C]{\frac{S!}{(S-C)!}}$$

The flexibility equilibrium similar to figure 1 is illustrated below in table 2. It shows the number of providers necessary to justify a combination of services available and services chosen without losing flexibility.

Table 2. Flexibility equilibrium frontier with both lexicon size and subset size.

Services Availiable	Services Chosen: 1	2	3	4	5	6	7	8	9	10	11	12
1	1	-	-	-	-	-	-	-	-	-	-	-
2	2	1.414	-	-	-	-	-	-	-	-	-	-
3	3	2.449	1.817	-	-	-	-	-	-	-	-	-
4	4	3.464	2.884	2.213	-	-	-	-	-	-	-	-
5	5	4.472	3.915	3.310	2.605	-	-	-	-	-	-	-
6	6	5.477	4.932	4.356	3.728	2.994	-	-	-	-	-	-
7	7	6.481	5.944	5.384	4.789	4.141	3.380	-	-	-	-	-
8	8	7.483	6.952	6.402	5.827	5.217	4.549	3.764	-	-	-	-
9	9	8.485	7.958	7.416	6.853	6.265	5.640	4.954	4.147	-	-	-
10	10	9.487	8.963	8.426	7.873	7.299	6.698	6.058	5.356	4.529	-	-
11	11	10.488	9.967	9.434	8.887	8.324	7.739	7.126	6.473	5.756	4.909	-
12	12	11.489	10.970	10.440	9.899	9.343	8.770	8.176	7.551	6.885	6.153	5.289

Note that for a given number of services, the number of organizations increases at a declining rate. This leads to the following proposition:

Proposition 4: The constraining costs to a system, in terms of reduced flexibility in service sequence, from establishing a sequence-standard increases at a declining function of the number of services chosen to provide in the process.

Process Definition by Constraint

Next, consider that management imposes a sequential restriction, such as 'service A must be done first'. This case results in a loss of

9) $S!-(S-1)!$

Even if many of the services provided must be performed in a specific order, because the growth rate of combinatorial functions is orders of magnitude larger than polynomial functions the resulting number permutations will be large. The resulting loss of flexibility with S services provided and N services provided that must be performed in a given order is

10) $S!-(S-N)!$

Table 2 shows an example that growth rate of equation 9 is near that of equation 4. Equation 6 also approaches equation 3 at a relatively small number of services provided due to the combinatorial explosion in the number of possibilities. The implication is that what appears to be a relatively flexible process still results in a loss of sequential flexibility which is factorial in magnitude. We encourage the reader to explore these growth rates in a spreadsheet or other package. Also, note that since the function is discrete in nature the function is only calculable at integer values.

Table 3. Growth rate of factorials

S	S!-1	S!-(S-1)!	Difference
1	0	0	0.0%
2	1	1	0.0%
3	5	4	20.0%
4	23	18	21.7%
5	119	96	19.3%
6	719	600	16.6%
7	5,039	4,320	14.3%
8	40,319	35,280	12.5%
9	362,879	322,560	11.1%
10	3,628,799	3,265,920	10.0%
11	39,916,799	36,288,000	9.1%

Another implication is that given the growth rate of combinatoric functions allowing a sequentially open set, while specifying a fixed number of invalid sequences, will preserve a large degree of flexibility. The point here is that with a relatively small number of "exceptions" it becomes infeasible to enumerate all possible paths, but a standard which fixes tasks to a particular point in the process reduces a large amount of flexibility. This leads to the following proposition:

Proposition 5: A constraint-based approach to process definition is superior to an enumeration-based approach when the environment has sequential variety.

Approximation of the function

Given the factorial function in our models outlined above it becomes difficult to calculate beyond about 150 services, because the resulting factorial exceeds the limits of floating point numbers in 32-bit computing. To calculate the factorial component of this model beyond this point Stirling's approximation can be used (Stirling, 1730).

$$n! \approx \sqrt{2\pi n}\left(\frac{n}{e}\right)^{n} \tag{11}$$

Which, substituted into equation 6 yields

$$P = \left(2\pi S\right)^{\frac{1}{2S}}\left(\frac{S}{e}\right) \tag{12}$$

or substituted into equation 8 yields

$$P = \sqrt[C]{\frac{\sqrt{2\pi S}\left(\frac{S}{e}\right)^{S}}{\sqrt{2\pi(S-C)}\left(\frac{S-C}{e}\right)^{S-C}}} \tag{13}$$

Next steps

Extensions to the model

We plan to extend the model in a couple ways. First, we plan to include transaction costs of switching work from one provider to another provider. This would be accomplished by including a P x P matrix H in which each $H_{p,p}$ corresponds to the cost handoff between a given service provider to another given supplier. Second, we plan to address the assumption that each service provider can perform each service at the same cost. In practice, it is likely that given a set of service providers some providers will be more efficient than others. We will address this by including a P x S matrix weighting matrix where each $W_{p,s}$ represents the costs for provider *P* to perform service *S*.

Case studies

We plan to investigate the extent to which process standards actually do constrain sequence, and the potential effect this has on flexibility and value. We plan to do this in two contexts: SOA (service-oriented architecture) and IOS (inter-organizational systems).

Discussion

Decision Biases

Tversky and Kahneman (1974) outline many different types of cognitive biases of availability. One of these, the bias of imaginability, relates to the underestimation of many less used mathematical functions, such as combinatorial or factorials. Individuals underestimate the number of possibilities resulting from combinatorial functions due to this cognitive bias (Tversky and Kahneman, 1973), leading to adverse economic consequences in terms of risk-aversion and overweighting low probability events (Kahneman and Tversky, 1979). As a result of these biases it is unlikely that either system designers or managers will recognize the magnitude of flexibility loss that results from adoption of a conventionally defined process standard.

Potential benefits of constraint-based standardization

In a service context, the need for flexibility is paramount. Traditional processes (e.g. classic manufacturing) have many possible production sequences that are infeasible due to physical constraints. Therefore, given a traditional process with number of tasks the potential set of production sequences is far less than in a service context where the output is intangible. Also, in a traditional context the producer is in control of production. Consumers act as co-producers in a service context, so the set of feasible production sequences is orders of magnitude larger than in a traditional context. Our model shows how seemingly small constraints upon sequencing can lead to enormous reductions in flexibility. A constraints-based approach addresses the weakness in traditional process definition approaches by effectively enumerating what *is not* feasible, rather than what *is* feasible. Taking a constrain-the-open-set approach is more suited to a service context, where production sequence is socially and institutionally constructed.

Conclusion

Provisioning of services often entails co-production and measurement of output is difficult and often somewhat subjective. As a result of this, in services production sequence is highly variable and often not known in advance. Some customers want their pudding first. Traditional process definitions begin with the goal of finding the “one best way” to accomplish an end. In a traditional context, such as manufacturing, lack of variation is a sign of quality. In services, because of the high degree of uncertainty, the goal is more often to accommodate as many ways as possible. The ability to accommodate variation is a sign of quality in services. In this paper we developed an analytic model which showed that using a conventional “one best way” or enumeration-based approach to process definition, in a service context, the constraining aspects of standardization are likely to outweigh the enabling aspects of standardization in terms of much needed flexibility. Additionally, we show that the nature of the loss function is such that system designers and managers are likely to severely underestimate the magnitude of loss. Also, we show that proscribing the infeasible set is superior to prescribing the few allowable sequences of action, when flexibility is desired. Finally, while we have framed this as a model of service processes, we feel that the abstract nature of the model allows one to generalize as to the inherent tradeoffs between enabling benefits and constraints of standardization in terms of standardization of both lexicon and sequence.

References

Argote, L., 1982, “Input Uncertainty and Organizational Coordination in Hospital Emergency Units”, *Administrative Science Quarterly*, v. 27, pp. 420-434

Bala, H. & Venkatesh, V, 2007. “Assimilation of Interorganizational Business Process Standards”. *Information Systems Research*18 (3) pp340-362

Bowen, J., and Ford, R., 2002, “Managing Service Organizations: Does Having a “Thing” Make a Difference?”, *Journal of Management*, 28(3), pp. 447–469

Carmen, J., & Langeard, E.,1980, “Growth Strategies of Service Firms”, *Strategic Management Journal*, 1(1), pp.7-22

Cronin, J., & Taylor, S.,1994, “SERFPERF Versus SERVQUAL: Reconciling Performance-Based and Perception-Minus-Expectations Measurement of Service Quality”, *Journal of Marketing*, 58(1), pp.125-131

David, P. & Greenstein, S. “The Economics of Compatibility Standards: An Introduction to Recent Research”, *Economics of Innovation and New Technology,* 1(1&2), pp3-41

Feldman, M. S., 2000, “Organizational Routines as a Source of Continuous Change”, *Organization Science*, 11(6), pp. 611-629.

Feldman, M. S., & Pentland, B., 2003, “Reconceptualizing Organizational Routines as a Source of Flexibility and Change”, *Administrative Science Quarterly*, 48(1),pp. 94-118.

Gosain, S. Malhotra, A., El Sawy, O. A., 2004-05 “Coordinating for Flexibility in eBusiness Supply Chains.” *Journal of Management Information Systems,* 21 (3) pp. 7-45

Kahneman, D., & Tversky, A., 1979, “Prospect Theory: An Analysis of Decision under Risk”, *Econometrica*, 47(2), pp. 263-291

Keaveney, S., 1995, “Customer Switching Behavior in Service Industries: An Exploratory Study”, *Journal of Marketing*, 59(2), pp. 71-82

Kumar, A. and Zhao, L., 1999, “Dynamic Routing and Operational Controls in Workflow Management Systems”, *Management Science*, 45(2), pp. 253-272

Malone, T., Crowston, K., Herman, G., 2006, *Organizing Business Knowledge: The MIT Process Handbook*, MIT Press, Cambridge, Mass.

Markus, M. L., Steinfield, C., Wigand, R., & Minton, G., 2006, “Industry-Wide Information Systems Standardization as Collective Action: The Case of the Residential Mortgage Industry”, *MIS Quarterly*, 30, pp 439-465

Oakland, J.S., 1996, *Statistical Process Control*, Butterworth-Heinemann, Woburn, MA.

Parasuraman, A., Zeithaml, V., & Berry, L., 1985, “A Conceptual Model of Service Quality and Its Implications for Future Research”, *Journal of Marketing*, 49(3), pp. 41-50.

Pine, B. J., & Gilmore, J. 1999. *The experience economy.* Boston: HBS Press.

Shostack, G., 1977, “Breaking Free from Product Marketing”, *Journal of Marketing*, 41(2), pp.73-80.

Stirling, J. , 1730, *Methodus differentialis, sive tractatus de summation et interpolation serierum infinitarium*. London. English translation by Holliday, J. *The Differential Method: A Treatise of the Summation and Interpolation of Infinite Series*. 1749.

Taylor, F.W., 1911*, Principles of Scientific Management*, New York.

Tversky, A., & Kahneman, D. ,1973, “Availability: A heuristic for judging frequency and probability”, *Cognitive Psychology,* 5(2), pp.207-232.

Tversky, A., & Kahneman, D. ,1974, “Judgment under Uncertainty: Heuristics and Biases”, *Science*, 185(4157), pp.1124-1131.

Zeithaml, V., Parasuraman, Z., & Berry, L. (1990). *Delivering Quality Service: Balancing Customer Perceptions and Expectations.* New York: The Free Press.